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Full-Length Research Article

Dairy Cattle Feed Quantity, Nutrient Balance and Feed Scarcity Coping Mechanism in Kedida Gamela *Woreda*, Kembata Zone, Southern Ethiopia

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ABSTRACT

The study was conducted in Kedida Gamela Woreda of Kambata Tambaro Zone, Southern Ethiopia, with the goals of estimating the amount of available feed resources, estimating the nutrient balance, and assessing the coping mechanism of dairy cattle in relation to agro-ecologies and seasons in the study area. Multistage sampling procedures were used. The mean dry matter (DM) produced per household in the highland and midland was 3.4 and 3.7 tons ($P < 0.05$), respectively, while the required amount was 8.5 and 8 tons, with a negative balance of 5.1 and 4.3 tons ($P < 0.05$). The mean DM produced per household during the wet and dry seasons was 4.1 and 3.1 tons ($P < 0.05$), respectively, while the required amount was 7.9 and 8.6 tons, with a negative balance of 3.9 and 5.5 tons ($P < 0.05$). As a result, farmers increased their use of concentrates and non-traditional feeds, improved forage production, transferred stocks to relatives, and reduced herd size as coping mechanisms in response to feed scarcity.

Keywords: crude protein, dry matter, metabolized energy, nutrient requirement

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1. INTRODUCTION

In Ethiopia, livestock is an important part of the agricultural sector. Cattle are the most common livestock in Ethiopia (CSA, 2017). Despite its large dairy cattle population, Ethiopia has a very low milk production per cow per day. The low productivity is primarily due to a lack of both quantity and quality feed (Belay *et al*., 2011). Livestock, particularly cattle, plays an important role in rural people's livelihoods in Kedida Gamela woreda, as in other parts of the country. However, feed scarcity in both quantitative and qualitative dimensions is a major impediment to the development of the livestock sub-sector in the area. Natural pasture, crop residue, fodder, weeds from cropland, improved forage, enset, and bananas are all examples of feed resources (Mengistu *et al*., 2016). With the rapid increase in human population and increasing demand for food, grazing and browsing resources are steadily diminishing as they are converted to arable lands and are restricted to areas of low value. Much of the available feed resources are used to support animal maintenance, leaving a little surplus for production. Furthermore, there is marked seasonality in the quantity and quality of available feed resources as a result of various environmental determinants (drought, frost, etc). (Jimma *et al*., 2016). Dry matter (DM), crude protein (CP), and metabolisable energy (ME) supplied by various feed resources are negatively balancing the annual requirements of the total tropical livestock unit (TLU) (Yisehak and Geert, 2014). In this regard, the Kedida Gamela woreda is not an outlier, and similar trends can be observed from time to time. The available feed resource should match the production systems used and the number of animals in a given area for optimal livestock productivity. Most of the previous research on the assessment of feed resources in various parts of the country, particularly in the current study area, only indicated a lack of feeds without quantifying the amount of dry matter and determining whether it is sufficient for the total number of tropical livestock units available in the area. The present study, therefore, is the study was conducted in Kedida Gamela Woreda of Kambata Tambaro Zone, Southern Ethiopia, with the goals of estimating the amount of available feed resources, estimating the nutrient balance, and assessing the coping mechanism of dairy cattle in relation to agro-ecologies and seasons in the study area.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The research was carried out in the Southern Nations, Nationalities, and Peoples Regions of Kedida Gamela woreda (SNNPRS). This woreda's altitude ranges from 1700 to 3028 meters above sea level and is located between 707′30″ N and 7021′30″ N Latitude and 37050′0″ E and 3805′0″ E Longitude. The woreda has a total area of 176 km^2. Its land area is divided into 7% highland (Dega) and 93% Weyna Dega (sub-tropical climate). Annual rainfall ranges from 1000 to 1400 mm, while annual mean temperatures range from 15 ^{o}C to 24 ^{0}C, with a mean value of 19 ^{0}C (SNNPRS, BoFED, 2010).

2.2. Sampling Procedure

Multiple-stage sampling procedures were used. First, the woreda was divided into two sections based on agro-ecological classification: highland and midland. Based on this, three kebeles from the midland and two from the highland, for a total of five kebeles, were chosen on purpose based on their livestock potential and accessibility. Finally, households were chosen from each kebele using a systematic random sampling technique. The probability proportional sample size-sampling technique was used to determine the total sample size for the household interview (Cochran, 1997).

$$no = \frac{Z^2 * (P)(q)}{d^2}$$

Where, n_o= desired sample size according to Cochran's (1997) when population greater than 10,000**;**

Z = standard normal deviation (1.96 for 95% confidence level)**;**

P = 0.12 (proportion of population to be included in sample i.e., 12%)**;**

q= 1-0.12 i.e. (0.88);

d = is degree of accuracy desired (0.05), 5% error term.

As a result of the above formula, 162 households were included in the study.

2.3. Quantity Estimation of Available Feed Resource

The total amount of DM available from natural pastures in the study area was calculated by multiplying the average value of grazing landholding by the natural pasture's per hectare DM output multiplied by a conversion factor of 2 tDM/ha/year (FAO, 1987). According to FAO, the quantity of available crop residues (DM basis) was estimated from the total crop yields of the households (1987). Conversion factors for barley, wheat, tef, and oats are 1.5, maize is 2, pulse and oil crop straws are 1.2, and sorghum is 2.5. However, the feed DM obtained from enset, banana, and improved forage species was calculated by multiplying the crop area by the estimated annual DM yield/ha (FAO, 1987), which is 8,000 kg. The amount of available DM in fallow land and aftermath grazing was calculated by multiplying the available land by the conversion factors of 1.8 for fallow land and 0.5 for aftermath grazing, as determined by FAO (1987). The potential fodder yield of the identified shrubs and trees was estimated by measuring stem circumference with a measuring tape and using the Petmak equation (1983). As a result, the leaf yield of fodder trees was estimated using the allometric equation log W = 2.24log DT-1.50. Where W denotes leaf yield in kilograms dry weight and DT denotes trunk diameter (cm) at 130 cm height. During the cross-sectional questionnaire survey, farmers were interviewed to determine the quantity (DM basis) of conventional and non-conventional concentrates (Supplements) available for each household. The following equation predicted the metabolisable energy (ME) content of the feedstuffs (Abate and Meyer 1997).

ME (MJ/kg DM) = 5.34-0.1365CF + 0.6926NFE - 0.0152NFE2 + 0.0001NFE3; R2 = 0.45, P 0.0001;

NFE = nitrogen free extract (percent NFE = percent DM - (percent EE + percent CP + percent ash + percent CF) McDonald et al (2010).

DM = dry matter; EE = ether extract or crude lipid; CP = crude protein; CF = crude fiber)

2.4. Estimation of the Feed Supply-Feed Requirement Balance

Total DM production from natural pasture, crop residues, crop aftermath, fodder trees and shrubs, and other nontraditional feed resources was compared with the DM requirements of the cattle population in the sampled households. Using Gryseels' conversion factors, the number of dairy cattle was converted into tropical livestock units (TLU) (1988). According to Kearl (1982), the daily DM requirement for maintenance of 1 TLU (250 kg livestock) which consumes 2.5 percent of its body weight is 6.25 kg DM/d and crude protein (CP) content of 58 g/kg DM and 5.2 MJ ME/kg DM diet is used, whereas 1 LLU (450 kg livestock) consumes 10 kg DM/d. For maintenance, a crude protein content of 70 g/kg DM and an energy content of 8.368 MJ ME/kg DM diet are used (WIIAD, 1992).

2.5. Data Analysis

All survey data were analyzed using Statistical Packages for Social Science (SPSS) version 20. (SPSS, 2011). Cross tabs were used to test statistical variations in categorical data, with $P < 0.05$ indicating significant differences. The numerical data, descriptive statistics were subjected to a two-way analysis of variance (ANOVA) using SPSS's general linear model procedure. $P<0.05$ was chosen as the level of significance. The analyzed data were presented using tables, figures, percentages, means, and standard errors. This study was employed the following statistical models:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \alpha\beta_{ijk} + \Sigma_{ij}$$

Where; yijk = quantity and quality of available feed resources; μ = overall mean

α_i = the effect of ith location/agroecology (I =1, 2, 3)

β_j = the effect of j^{th} season (j= 1, 2)

Σ_{ijk}= random error

3. RESULTS AND DISCUSSIONS

3.1. Characteristics of the Household

The study area's agro-ecological classification had no effect on gender, education level of household head, or family size (Table 1). In the current study, the majority of respondents (70 percent) had formal education, which is important for understanding extension messages and realizing the importance of new technologies in a short period of time. According to Ofukou et al. (2009), farmers with a higher level of education typically adopt new technologies faster than farmers with a lower level of education. The study area had a relatively large family size. Large family sizes were thought to be very important for dairy activities that create suitable conditions for feeding, watering, and herding dairy cattle.

Table 1. The household characteristics of the study area

Variables	Location				
	Highland (n=64)	**Midland (n=96)**	**Overall**	**SEM**	**P value**
Sex (%)					0.946
Male	64.1	63.5	63.7		
Female	35.9	36.5	36.3		
Education (%)					0.564
Illiterate	28.1	30.2	29.4		
Primary	42.2	40.6	41.2		
Secondary	21.9	26.0	24.4		
College and above	7.8	3.1	5		
Income (%)					0.001
Low	46.9	16.7	28.7		
Medium	48.4	54.2	51.9		
High	4.7	29.2	19.4		
Age (M)	44.5	44.5	44.5	0.585	0.976
Family size (M)	6.11	6.03	6.06	0.118	0.746

n=number of respondents; M=mean; SEM=standard error of the mean

3.2. Landholding and Land Use Pattern

Land is the most important limiting factor for dairy cattle production in the study area, and the amount of production is heavily influenced by the quality and quantity of available land. In contrast to family size, however, landholding per household is decreasing over time. The agro-ecological classification of the study area had no effect on household landholding (Table 2). Sisay (2006) found 1.66, 2.03, and 6.17 ha in the Debark, Layarmachiho, and Metema districts, respectively, and Zewdie (2010) found 4.2 ha in Ziway, Central Rift Valley. In the study area, the average private grazing land of the household was affected by agro ecologic classification ($P < 0.05$).

Table 2. Landholding and land use pattern in the study area

Variable	Agro-ecology				
	Highland (n= 64)	Midland (n= 96)	Overall (n= 160)	SEM	P value
Total land (ha^1)	0.97	0.94	0.95	0.025	0.662
Crop land (ha^1)	0.44	0.40	0.42	0.014	0.221
Homestead (ha^1)	0.07	0.07	0.06	0.005	0.759
Private grazing (ha^1)	0.07^a	0.05^b	0.06	0.005	0.025
Wood land (ha^1)	0.04	0.03	0.04	0.004	0.221
Forage and pasture (ha^1)	0.09	0.13	0.11	0.014	0.360
Others (ha^1)	0.25	0.26	0.26	0.010	0.440
Land allocation for field crop (ha^1)					
Maize	0.08^b	0.16^a	0.13	0.006	0.001
Teff	0.03^b	0.14^a	0.09	0.007	0.001
Wheat	0.21^a	0.06^b	0.12	0.008	0.001
Barely	0.11^a	0.02^b	0.06	0.007	0.001
Haricot bean	0.07^b	0.12^a	0.09	0.009	0.007
Irish potato	0.07	0.06	0.07	0.005	0.188

[ab] Means in the same row without a common letter are different at $P < 0.05$; h=hectare

3.3. The Livestock Population in the Study Area

The study area's agroecological classification and seasons had no effect on total livestock holdings per household (P > 0.05; Table 3). In contrast to the current study, Endale (2015) reported an average TLU of 7.97, 0.74, 0.46, 0.78, and 0.07 for cattle, sheep, goats, donkeys, and poultry in Meta Robi district and (5.35), sheep (0.49), goats (0.03), donkeys (0.22), and poultry (0.02) in Jeldu district (2012).

Table 2. The livestock population in the study area in TLU

Variable	Cattle Mean	Sheep (TLU) Mean	Goat (TLU) Mean	Donkey (TLU) Mean	Poultry Mean	Total Mean
Agroecology						
Highland	6.1	0.07	0.09^{a}	0.26	0.01^{b}	6.5
Midland	5.8	0.08	0.05^{b}	0.21	0.02^{a}	6.2
Season						
Wet	5.6^{b}	0.99^{a}	0.11^{a}	0.3^{a}	0.02^{a}	6.1
Dry	6.3^{a}	0.05^{b}	0.03^{b}	0.2^{b}	0.01^{b}	6.6
Significance						
Agroecology	0.345	0.521	0.001	0.258	0.006	0.228
Season	0.007	0.001	0.001	0.026	0.001	0.062
Interaction	0.919	0.267	0.001	0.979	0.429	0.998

[ab] Means with different superscripts along column within the same variable are different at P < 0.05; tropical livestock unit

3.4. Dry matter, Crude Protein and Metabolizable Energy Availability, Requirements and Estimated Balance of Feeds

Natural pasture, crop residues, concentrates, forages, fodder trees and shrubs, and others were discovered to be the primary feed resources for dairy cattle in the study area (enset, banana, sugar cane and non-convention feed). The mean total DM produced per household was higher (P < 0.05) in the midland agroecology than in the highland agroecology (Table 4). This could be because midland agroecology produces more improved forage and uses more concentrates than highland agroecology.

According to Kearl (1982), the daily DM requirement for one TLU (250 kg livestock) is 6.25 kg DM/day, whereas one large livestock unit (LLU) requires 10 kg DM/day (WIIAD, 1992). As a result, for existing TLU units, the feed balance in terms of

DM yield in highland agroecology per household to mean TLU value of 6.5 results in 8.5 tons of DM for 6 months (with the negative balance of 5.1 tons). For existing TLU units, the feed balance in terms of DM yield in midland agroecology per household to mean TLU value of 6.2 resulted in 8 tons of DM for 6 months (with the negative balance of 4.3 tons). In highland and mid-altitude areas, the average tropical livestock unit (TLU) per household was 6.5 and 6.2 TLU, respectively (Table 3), whereas the total dry matter (DM) required for 6 months is 8.5 and 8 tons, respectively (Table 5). In highland and mid-altitude areas, total dry matter (DM) production was 3.4 and 3.7 tons, respectively (Table 4). The total feed balance in terms of DM for six months in highland and mid-altitude areas was 5.1- and 4.3-tons DM, respectively (Table 5). The mean total DM produced per household was higher ($P < 0.05$) during the wet season than during the dry season (Table 4). This is most likely due to the greater availability of natural pasture and improved forage. For existing TLU units, the feed balance in terms of DM yield during the wet season per household to mean TLU value of 6.1 resulted in 7.9 t of DM for 6 months (with the negative balance of 3.9 t). For existing TLU units, the feed balance in terms of DM yield during the dry season per household to mean TLU value of 6.6 resulted in 8.6 tons of DM for 6 months (with the negative balance of 5.5 tons).

The average tropical livestock unit (TLU) per household in the wet and dry seasons was 6.1 and 6.6 TLU, respectively (Table 3), while the total dry matter (DM) required for 6 months was 7.9 and 8.6 tons, respectively (Table 5). The total dry matter requirement was unaffected by seasonal variation (Table 5). About 4.1 and 3.1 tons of total dry matter (DM) were produced during the wet and dry seasons, respectively (Table 4). The total feed balance in terms of DM for 6 months during the wet and dry seasons was 3.9- and 5.5-tons DM, respectively (Table 5). In general, this result indicated that dry matter production fell short of livestock requirements. This result was also consistent with previous studies by Mergia et al. (2014), Yisehak and Geert (2014), Zewdie (2010) for Ziway, Central Rift Valley, and Yishitile (2008) for Alaba Woreda, which found that annual dry matter production was lower than annual livestock requirements.

Table 4. Feed resource category and supply per household based on DM, CP, and ME

Variables	**DM supply by ton (t) from different feed resources**						
	NP (t)	**CR (t)**	**AIBP (t)**	**Forage (t)**	**Fodder (t)**	**Others (t)**	**Total DM (t)**
Highland	0.6^{a}	0.6	0.5^{b}	0.5^{b}	0.3^{b}	0.9	3.4^{b}
Midland	0.4^{b}	0.7	0.6^{a}	0.8^{a}	0.4^{a}	0.8	3.7^{a}
Wet	1.1	0	0.4^{b}	1.2	0.5^{a}	0.8	4.1^{a}
Dry	0	1.3	0.6^{a}	0	0.3^{b}	0.9	3.1^{b}
Significance							
Agroecology	0.001	0.077	0.002	0.005	0.002	0.489	0.006
Season	0.001	0.001	0.001	0.001	0.001	1.000	0.001
Interaction	0.001	0.077	0.259	0.005	0.105	1.000	0.469
	CP supply by ton (t)						
Highland	0.05^{a}	0.03	0.12^{b}	0.04^{b}	0.07^{b}	0.2	0.5^{b}
Midland	0.03^{b}	0.04	0.13^{a}	0.07^{a}	0.08^{a}	0.2	0.51^{a}
Wet	0.08	0	0.1^{b}	0.11	0.1^{a}	0.1	0.6^{a}
Dry	0	0.07	0.2^{a}	0	0.06^{b}	0.2	0.4^{b}
Significance							
Agroecology	0.001	0.077	0.002	0.005	0.002	0.489	0.001
Season	0.001	0.001	0.001	0.001	0.001	1.000	0.001
Interaction	0.001	0.078	0.258	0.005	0.105	1.000	0.145
	ME supply by MJ/t						
Highland	6.1^{a}	5.3	4.4^{b}	3.5^{b}	2.9^{b}	7.3	29.5^{b}
Midland	4.2^{b}	5.9	5.4^{a}	5.6^{a}	3.3^{a}	7.6	32.1^{a}
Wet	10.3	0	4.1^{a}	9.1	4^{a}	7.5	34.9^{a}
Dry	0	11.3	5.8^{b}	0	2.2^{b}	7.5	26.7^{b}
Significance							
Agroecology	0.001	0.078	0.002	0.005	0.002	0.489	0.018
Season	0.001	0.001	0.001	0.001	0.001	1.000	0.001
Interaction	0.001	0.077	0.259	0.005	0.105	1.000	0.821

[ab] Means with different superscripts along column within the same variable are different at P < 0.05; DM=dry matter; CP=crude protein; ME=metabolizable energy; NP=natural pasture; CR= crop residues; AIBP=agro industrial by-products

The mean total CP produced per household in the highlands was lower (P < 0.05) than in the midlands. This was due to the availability of high CP-containing feeds (improved forage) in a large proportion at midland agroecology. According to FAO (1986), the crude protein requirement for one tropical livestock unit (250 kg live weight) was 58 g/kg DM per day, and the requirement for one livestock unit was 70 g/kg DM (WIIAD, 1992). As a result, the 6 months mean required CP per household in the Highlands for the TLU was 0.52 CP tons, with a negative balance of 0.07 tons CP (Table 5). The six-month average required CP per household in the midland for the TLU was 0.5 CP tons, with a positive balance of 0.02 tons CP (Table 5). In contrast, the TLU's 6 months mean required CP per household during the wet season was 0.5 CP tons with a positive balance of 0.06 tons CP (Table 5) and 0.53 CP tons with a negative balance of 0.12 tons during the dry season (Table 5). This result indicated that CP production fell short of livestock requirements. The current study agrees with Mergia *et al*. (2014) in the Baresa watershed, Yisehak and Geert (2014) in the Gilgel Gibe catchments of Ethiopia, and Zewdie (2010) in the Ziway, Central Rift Valley. The amount of crude protein (CP) required was unaffected ($P > 0.05$) by the study area's two agro-ecologies or seasonal differences. The energy requirement for one TLU (250 kg body weight) was calculated to be 5.2 MJ ME/kg DM or 32.1 MJ/day (MAFF, 1987), whereas one LLU required 8.368 MJ ME/kg DM (WIIAD 1992). As a result, the metabolizable energy (ME) produced and required per highland household for the TLU were 29.5- and 43.9-tons MJ ME, respectively, with a negative balance of 14.3 tons MJ ME (Table 5). The metabolizable energy (ME) produced and required per household in the midland for the TLU were 32.1- and 41.6-tons MJ ME, respectively, with a negative balance of 9.6 tons MJ ME (Table 5).

Two agro-ecologies had no effect on the metabolizable energy (ME) produced ($P > 0.05$). During the wet season, the metabolizable energy (ME) produced and required per household for the TLU were 34.9- and 41-tons MJ ME, respectively, with a negative balance of 6.1 tons MJ ME (Table 5). During the dry season, the metabolizable energy (ME) produced and required per household for the TLU were 26.7- and 44.5-tons MJ ME, respectively, with a negative balance of 17.8 tons MJ ME (Table 5). The ME produced per household was greater ($P < 0.05$) during the wet season than during the dry season, whereas the metabolizable energy (ME) required per household was unaffected by seasonal differences ($P > 0.05$).

Table 5. Estimated yearly differences in feed resources availability, required and balance per household

Nutrients	Variables		Available, tons	Required, tons	Balance, tons
DM	**Agroecology**	Highland	3.4^b	8.5	-5.1^a
		Midland	3.7^a	8	-4.3^b
	Season	Wet	4.1^a	7.9	-3.9^b
		Dry	3.1^b	8.6	-5.5^a
	Significance	Agroecology	0.006	0.232	0.025
		Season	0.001	0.059	0.001
		Interaction	0.469	0.991	0.795
CP	**Agroecology**	Highland	0.5^b	0.52	-0.07^a
		Midland	0.61^a	0.5	0.09^b
	Season	Wet	0.6^a	0.5	0.10^b
		Dry	0.4^b	0.53	-0.12^a
	Significance	Agroecology	0.001	0.232	0.001
		Season	0.001	0.059	0.001
		Interaction	0.145	0.991	0.357
ME	**Agroecology**	Highland	29.5^b	43.9	-14.3^a
		Midland	32.1^a	41.6	-9.6^b
	Season	Wet	34.9^a	41	-6.1^b
		Dry	26.7^b	44.5	-17.8^a
	Significance	Agroecology	0.018	0.232	0.013
		Season	0.001	0.059	0.001
		Interaction	0.821	0.991	0.908

[ab] Means with different superscripts along column within the same variable are different at $P < 0.05$

3.5. Major Coping Strategies to Scarcity of Feed in the Study Area

The current study's findings are similar to those of Duguma and Janssens (2016) for Jimma town, Ethiopia. Farmers used agro-industrial by-products and concentrate mix to cope with dry season feed scarcity, as well as conserved hay, non-conventional feeds, purchasing green feeds when available, and reducing herd size, according to the report of Jayasuriya (2002) also reported that smallholder farmers in developing countries who face limited feed availability for feeding dairy cattle use what is locally available to them at no or low cost.

Table 6. Major coping strategies to scarcity of feed in the study area

	Variables	Highland (n=64)		Midland (n=96)	
		Index value	Rank	Index value	Rank
Wet season	Feed preservation as straw and hay	0.375	1	0.415	1
	Using browse trees	0.154	2	0.108	4
	Use of improved forage production	0.143	3	0.238	2
	Supplementation	0.107	4	0.119	3
	Transferring stocks to relatives	0.089	5	0.035	6
	Destocking	0.065	6	0.029	7
	Forage purchase	0.049	7	0.049	5
	Traveling long distance	0.018	8	0.007	8
Dry season	Feed preservation as straw and hay	0.313	1	0.293	1
	Using browse trees	0.185	2	0.135	3
	Use of improved forage production	0.089	6	0.118	5
	Supplementation	0.138	3	0.186	2
	Transferring stocks to relatives	0.112	4	0.047	7
	Destocking	0.096	5	0.125	4
	Forage purchase	0.049	7	0.089	6
	Traveling long distance	0.018	8	0.007	8

4. CONCLUSIONS

In general, estimation of available feed resources reveals a feed supply scarcity in the study area. The total DM, CP, and ME yield produced and required in the study area for the existing tropical livestock unit/large livestock unit per household was discovered to be in negative balance across seasons and agro-ecologies. Furthermore, as revealed by the majority of respondents, feed availability and seasonality were the most frequently occurring problems and constraints that could affect the development of dairy cattle production in the study area. Farmers, on the other hand, used coping strategies to deal with dry season feed scarcity, such as increased use of concentrates, non-traditional feeds, improved forage production, stock transfer to relatives, and herd reduction.

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Conflicting interests

The authors state that they do not have any competing interests.

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